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ABSTRACT

This study compared the effectiveness of two computer-based techniques for improving word recognition automaticity in children with mild reading difficulties. One of the techniques provided practice in identifying individual words out of context, while the other technique, referred to as repeated reading, provided practice reading specific words in context. Subjects were third and fourth graders with reading skills at approximately the 18th percentile. All children experienced practice using both techniques applied to different sets of words. The repeated reading technique was more effective than the context-free method in increasing the number of words in the children's sight vocabularies under both the context-free and the within-context assessments. The repeated reading technique also required less time per word to reach a specific mastery criteria, and thus was a more efficient instructional method. The text is supplemented by three tables. (EW)

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Effects of New Computer Technology on Increases in Children's Word Recognition Automaticity

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Abstract

This study compared the effectiveness of two computer based techniques for improving word recognition automaticity in children with mild reading difficulties. One of the techniques provided practice in identifying individual words out of context, while the other technique, referred to as repeated reading, provided practice reading specific words in context. Third and fourth graders with reading skills at approximately the 18th percentile were used as subjects. All children experienced practice using both techniques applied to different sets of words. The repeated reading technique was more effective than the context-free method in increasing the number of words in children's sight vocabularies under both context-free, and within-context assessment. The repeated reading technique also required less time per word to reach a specific mastery criteria, and thus was a more efficient instructional method.

Effects of New Computer Technology on Increases in Children's Word Recognition Automaticity

The ability to recognize whole words both rapidly and accurately is critical to the acquisition of beginning reading skills. Hence, a great deal of instruction for beginning, moderately delayed, and disabled readers is focused on increasing the speed and accuracy, or automaticity, with which students can recognize individual words. "Word recognition automaticity" is defined as the rapid and accurate processing of whole words as units, rather than the use of word attack skills to sound words out for identification. Individual words that are recognized automatically, regardless of whether they are encountered in text or in isolation are referred to as part of a reader's "sight word vocabulary." Consequently, to increase the number of words in a reader's sight word vocabulary, individual words must be recognized to a level of automaticity that includes criteria in both speed and accuracy.

This study examined two different computer based methods for increasing word recognition automaticity in young children with mild reading difficulties. It is responsive to the broadly accepted finding (Stanovich, 1986) that the primary reading difficulty of many poor readers lies at the word, rather than the text, level of processing. That is, the reading progress of many children in the early elementary grades is seriously limited by their inability to acquire skills in the rapid and accurate identification of words. Both theory and data suggest that difficulties in acquiring efficient word reading skills can be a primary cause of inability to comprehend the meaning of written material (Breznitz, 1987, Lesgold & Resnick, 1982; Perfetti, 1985).

When young children read individual words, they utilize at least three different methods for word recognition. Perfetti (1984) refers to these methods as involving different representational, or coding systems. Some words, for example are recognized as whole units. "Word identification occurs for these words when a string of visually encoded letters triggers the word representation constructed from frequent encounters with the word" (p.52). Other words are recognized because they contain specific letter strings or groups. These letter patterns have acquired a representational status because they occur

frequently in many different words. A third level of representation involves grapheme-phoneme correspondences. Words can be identified by approximating their spoken sound through analysis of sounds represented by individual letters and letter groups.

In his model, Perfetti (1984) suggests that children learn all three representational systems (whole words, high frequency letter groups, grapheme-phoneme relationships) simultaneously, and that they can provide useful support to one another in the acquisition of fluent word identification skills. In our research, we focus on methods to increase the number of words that children can recognize as whole units. This type of recognition usually requires less time than the other, more analytic methods of word recognition, and thus it is one way to help improve the reading speed of children who are experiencing difficulty in acquiring fluent reading skills.

Both of the methods for increasing word reading efficiency evaluated in this experiment utilize newly developed micro-computer technology to assist in presentation of instructional material and evaluation of responses. Although both of the techniques can be implemented using more standard materials, computer presentation greatly facilitates the measurement of response speed, which is a crucial variable in determining mastery of individual words.

One of the techniques involves context-free practice on word lists. This technique is used widely by teachers to increase the sight vocabulary of young children. It is essentially a form of pared-associate learning, in which children are shown individual words one at a time and must learn to respond quickly with appropriate pronunciation. Typically, word lists are practiced repeatedly, with the goal of producing rapid and accurate identification of words on the list.

The other technique we evaluated involves the repeated oral reading of short passages containing words that the children are to learn. This technique has been shown to produce generalized increases in reading fluency in disabled readers (Moyer, 1982), and there is evidence suggesting that it primarily affects the speed with which individual words are recognized (Rashotte & Torgesen, 1985). By repeatedly reading the same passage over and over, children acquire sufficient experience with individual words to allow development of the ability to respond to many of the words as whole word units.

Although both of these techniques have been evaluated positively in previous research, we are

aware of no studies that contrast their effectiveness with one another. Given the proliferation of computer based techniques for increasing reading skills, it is becoming increasingly important to understand, not only whether a technique is effective or not, but also about the relative efficacy of different techniques developed for the same purpose. In this study, we examine the relative effectiveness of both techniques to increase the sight word vocabulary of mildly impaired readers. Our dependent measures include: 1) short-term improvements in context-free word recognition speed; 2) long-term improvements in both within-context and out of context recognition speed; and 3) instructional time to achieve mastery as measured by a context-free diagnostic progress test.

Method

Subjects

Subjects were 16 third and fourth grade students attending an elementary school serving a population of mixed SES. The students were identified as moderately delayed readers by their classroom teachers. Their mean overall reading scores on the Comprehensive Assessment Program: Achievement Series (1985) was at the 18th percentile. The students were randomly assigned to two groups of equal size.

Assessment and Instructional Methods and Procedures

Sets of materials were developed by the principal investigator for both testing and instructional conditions. The assessment materials will be described first, followed by those used in instruction.

Word recognition screening test. A list of words introduced in the basal reader series during fourth grade was obtained from teachers. These words were divided into lists of 20 words and presented one at a time on the computer to each subject. The words were presented in lower case text, and students were instructed to respond as rapidly as possible. The examiner pressed a key immediately following an accurate pronunciation of a word. The computer recorded elapsed time between the appearance of a word and the button press indicating a correct response. After a correct response, or after five seconds had elapsed, the word disappeared and a new word appeared.

Analysis of responses to the screening test resulted in a list of eighty words, none of which were part of the sight vocabulary of any of the

subjects. A word was defined as part of a student's sight vocabulary if it was pronounced correctly in under three seconds. Although this criteria may seem a bit slow for recognition of sight words, response times in this study included the time it took for the examiner to recognize a correct response and push he timing button. Thus, response times are approximately .6-.8 seconds slower than they would have been with a more direct measurement technology. This delay in response measurement occurs consistently in all conditions of the study, so the basic comparative purposes are not compromised.

The 80 words were first stratified by parts of speech, and then randomly assigned to two sets. The first set consisted of sixty to-be-taught (target) words, and the second set consisted of twenty no treatment control words (non-target words) for which no instruction would be provided. The sixty target words were randomly assigned to four sets of fifteen words. Each set was then randomly assigned to one of four instructional weeks. The twenty non-target words were randomly assigned to four sets of five words. Each set was then randomly assigned to one of the four instructional weeks.

Diagnostic progress test. A diagnostic progress test was prepared for each of the four target word sets. The fifteen target words were presented once, in random sequence. The diagnostic progress test was administered during the instructional sessions in order to determine if words in a given practice set had been mastered. Again, mastery was defined as being able to pronounce a word accurately within three seconds. The testing format was identical to the format of the word recognition screening test.

Immediate context-free posttest. Four immediate context-free posttests were prepared. Each test consisted of a set of fifteen target words and a set of five non-target words presented once, in random sequence. These tests were administered on the Monday immediately following a week of practice for a given wordset. The testing format was identical to the format of the word recognition screening test.

Delayed context-free posttest. The delayed context-free posttest contained the sixty target words, and the twenty non-target words presented once, in random sequence. To prepare the test, 15 target words and 5 non-target words were randomly assigned to four sets of twenty words. This test was given three weeks following the conclusion of all training. The testing format was identical to the format of the word recognition screening test.

Delayed in-context posttest. the delayed in-context posttest consisted of the sixty target words

and the twenty non-target words presented once, in four novel stories. To construct the test, 15 target words and 5 non-target words were randomly assigned to four sets of twenty words. Then, four unique stories were developed, each containing a set of target and non-target words. The number of words in the stories ranged from 176 to 192, with an average length of 183 words. Mean readability of the stories was at the third grade level (Fry, 1968). Stories were presented in upper and lower case letters on the computer screen.

The students were instructed to read each story aloud once. They were told to read as fast as they could, without making any errors. They were informed that they would receive no help on difficult words. If they were unable to recognize a word within five seconds, the students were instructed to skip over the word and continue reading when they heard the examiner articulate the cue, "go on." All readings were taped for later analysis. A word was counted as part of a student's sight vocabulary if it was pronounced accurately within three seconds after the preceding word had been articulated, or if it was pronounced accurately within three seconds after the cue "go on" was heard. This test was given at the same time as the delayed context-free posttest. Half the subjects received this test first, while the other half was tested in the opposite order.

Repeated reading instructional materials. A set of stories, each consisting of three unique stories, was developed for each week of instruction. Each story contained the fifteen words in a target set presented once. The number of words in the stories ranged from 165 to 192, with an average length of 170 words. Mean readability of the stories was at the third grade level (Fry, 1968). Four multiple choice questions with three answer possibilities were prepared for each story. The questions referenced facts stated in the story; however, none of the questions nor answers included target words.

All stories were presented via the repeated reading shell of the Lessonmaster Authoring System (Brezin & Wager, 1987). This shell can present customized material in easy to read, upper and lower case text, for multiple presentations.

The students were instructed to read the stories aloud four times. They wee told that all reading errors would be corrected during the first two readings. The experimenter or assistant listened, but did not offer corrections during the final two readings. Immediately following each reading of a story, a unique multiple choice question was presented. Students received immediate feedback

concerning the speed with which they read the story and the accuracy of their response to the comprehension question. Following the four repetitions, they received graphic feedback, in the form of a bar graph that showed how fast they read each repetition of the story.

The students were allowed to play a computer dart game following the fourth reading of a story. They were told that they would earn extra playing time for correct answers and for faster reading speeds.

Students practiced a given set of target words with the repeated reading technique for four 20 minute sessions, or until they reached a specified criterion of performance on the target words (all the words correctly pronounced within three seconds). Once this criterion was met, practice continued for the present session, but the student did not have to return again that week. The diagnostic progress test was given immediately following the completion of four repetitions of each story. Thus, if after practicing the words by reading story 1 four times, the child accurately read all the target words within three seconds, performance criterion for the repeated reading condition had been met. If the criterion was not met following the fourth reading of stories 2 or 3, and four practice days had not elapsed, students continued to practice the target words with the repeated reading technique by rereading stories 1, 2, and 3. Practice on a given word set was discontinued after four 20 minute sessions, if mastery was not achieved.

Context-free condition. Three sets of context-free lessons were developed for each week of instruction. Each lesson contained all of the words in a given target set, and consisted of a series of multiple choice items. The lessons were developed using the Matching Shell of the Lessonmaster Authoring System (Brezin & Wager, 1987). The format selected from this shell involved the auditory presentation of a word, and a sentence using the word, via digitized speech followed by the visual presentation of three words in lower case text. The child's task was to choose the word pronounced by the computer. To respond to an item, a student first pressed a number on the keyboard that moved a box to surround the selected word, and then pressed another key to complete the response. Immediate feedback was provided following each response. For incorrect responses, and for responses not completed within five seconds, the box automatically moved to surround the target word. Distractor words appeared similar to the target word to discourage guessing based on

first letter consonant sounds, and number of syllables heard. The three practice lessons in a set differed only on the words used as foils in the multiple choice items.

After a student had responded to all of the items in a lesson, a chart appeared on the screen. It displayed the number of correct responses, incorrect responses, no responses, and the average number of seconds taken for correct responses. After responding to each item in a lesson four times, the student pressed a key to access the computer dart game. As in the repeated reading condition, the students were told that they would receive extra playing time for correct and for rapid responses. Following the dart game, students were administered the diagnostic progress test. Subsequent practice in the context free condition was administered following the same mastery rules as used in the repeated reading condition.

Experimental design and procedure

This study employed a within group, repeated measures design. The design was counterbalanced to ensure that all students received opportunity for equivalent intervals of instruction under both instructional conditions. All instruction and practice was provided in a computer lab setting using Apple II series microcomputers. For the first week, group 1 received repeated reading instruction on word set A, and group 2 received context-free instruction on word set A. Following instruction, the immediate, context-free posttest was administered to both groups consisting of word set A and non-treatment word set E. During the second week, group 1 received context-free instruction on word set B, and group 2 received repeated reading instruction on word set B. Following instruction, a context-free posttest was administered to both groups consisting of word set B and non-treatment word set F. This procedure was repeated for a total of four weeks, with the groups rotating until both groups had experienced each instructional condition twice. The delayed posttests were administered to all subjects three weeks after the last instructional week. A diagram of the experimental design can be seen in Table 1.

Insert Table 1 about here

Reliability of dependent measures

The inter-rater reliability for the number of words accurately pronounced within three seconds was determined by comparing the accuracy and speed measurements of two judges on twenty five percent of the total responses. Reliability was computed by dividing the number of agreements by the total number of agreements and disagreements. Reliability for the context-free testing format was 98.5%, while that for the in-context format was 98.7%.

Results

Although the non-treatment words were included in the posttests, they were not included in the statistical analyses. The basic purpose of the experiment was not to determine whether the instructional techniques were effective by themselves, but rather to answer questions about their relative effectiveness compared to each other. The non-treatment words are useful primarily to estimate the effects that experiences outside the experiment might have had on children's ability to read the words included in the practice sets. The Geisser-Greenhouse (negatively biased) conservative degrees of freedom were used in all tests of significance. This test adjusts for the fact that, in some cases, our data did not meet the requirements of compound symmetry and homogeneity of variance (Winer, 1971).

Table 2 presents the means and standard deviations for percentage of words in sight vocabulary, and actual speed of response for words in sight vocabulary, for each of the instructional conditions. It is important to remember that all 16 subjects contributed data to each cell of this table. That is, the data in each cell represent the mean of each subject's performance for two weeks of instruction in each condition. The descriptive data for non-treatment words is included for comparison.

Insert Table 2 about here

A 2 (instructional condition) x 3 (testing condition) ANOVA with repeated measures on both factors was conducted on the percentage of words in sight vocabulary under the three posttest conditions. The analysis indicated significant main effects of instructional condition F (1,15) = 20.84, $p < .01$, and testing condition F (2, 30) = 34.02, $p < .01$. In addition, there was a significant interaction between

instructional condition and testing condition F (2, 30) = 4.88, $p < .05$. Tests of simple main effects showed that there were significant differences ($p < .01$) between instructional conditions at all testing points, although the differences were smaller on the delayed, in-context measure than the other two posttests. The results indicate that the repeated reading technique was more effective than the context-free instructional method in increasing the number of words in the sight vocabulary of mildly reading disabled children.

The speed data indicate that, for words in sight vocabulary, both methods led to equivalent speed of responding. Visual comparison of data from the treatment conditions with the no-treatment words shows that subjects maintained relatively low levels of responding to unpracticed words in both context-free testing conditions. The relatively higher response values in the in-context testing condition indicate the degree of support for individual word reading provided by the context of the stories within which they were imbedded. This, of course, helps to explain the better performance in this testing conditions for words taught in both instructional conditions.

A second analysis was conducted to determine if the instructional condition under which words were taught differentially affected performance on posttests requiring in-context and context-free word recognition. A 2 (instructional condition) x 2 (testing condition) ANOVA was conducted using just the delayed in-context, and delayed context-free tests. The main effects of instructional condition F (1,15) = 16.22, $p < .01$, and testing condition F (1,15) = 42.61, $p < .01$ were significant; however, there was no significant interaction between instructional condition and testing condition F (1,15) = 2.12, $p > .10$. The failure to find an interaction suggests that the condition under which a word was taught (in context or out of context) did not differentially affect the probability that it would be part of a child's sight vocabulary under the two different (in-context or context-free) testing conditions.

A third analysis was conducted to determine if the two instructional techniques were differentially effective in producing learning that maintained its effects over a relatively long retention interval. A 2 (instructional condition) x 2 (testing condition) ANOVA with repeated measures was conducted on the percentage of words in sight vocabulary on the context-free (immediate and delayed) posttests. The main effects of instructional condition F (1,15) = 21.15, $p < .01$, and testing condition F (1,15) = 36.53, $p < .01$ were significant; however, there was no significant interaction between instructional

condition and testing condition F (1,15) = 2.38, $p > .10$. Thus, both techniques produced learning that was equally resistant to decay over time.

In order to answer questions about the relative efficiency of the two techniques in producing increases in sight vocabulary, we analyzed the results of the first administration of the diagnostic progress test. The first administration of the test was used in order to standardize measures across the two instructional treatments. That is, all students were given the test at least once for each of the four target word sets; however, some students did not have the opportunity to take more than one diagnostic progress test for a given set.

Two separate time to master measures were used. The first, "actual time," included the total time to use the lessons prior to attainment of mastery. The second, "adjusted time," excluded all noninstructional time (time to change discs, time for program to execute, etc.). The actual time measure evaluated the efficiency of the computer programs, and the adjusted time evaluated the efficiency of the instructional techniques.

The average number of minutes a student spent practicing a given target word prior to mastering the word was calculated for each student in each instructional condition, for both actual and adjusted time. To derive the "minutes per word" measures, both the actual and the adjusted time spent to master the words in a given 15 word target set were divided by the number of words mastered. Table 3 depicts the means and the standard deviations of the minutes per word measures for both actual and adjusted time.

Insert Table 3 about here

Two separate one way ANOVAs with repeated measures were conducted. The first analysis was performed on the minutes of practice to master a word for actual time, F (1,15) = 7.51, $p < .01$, and the second was performed on the average minutes of practice to master a word for adjusted time F (1,16) = 6.12, $p < .05$. The results of both analyses suggest that the repeated reading technique was more efficient, in terms of the time required to move words into a child's sight vocabulary, than the context-free method.

Discussion

On the basis of this study, our conclusion is that the repeated reading technique is more effective than context-free word practice in

improving the sight vocabulary of mildly handicapped readers. Of course, this conclusion is tied in important ways to the two particular computer programs that were used to implement each technique. The major evidence for our conclusion is that the repeated reading technique produced a higher percentage of words in sight vocabulary under all testing conditions, and that it required less instructional time to achieve mastery over each word.

At least two aspects of these findings require additional comment. First, it was mildly surprising to find that method of instruction did not differentially effect level of performance under two different methods of assessment. That is, words learned under context-free instruction were not more easily read in the context-free testing condition, nor did repeated reading instruction have a specially large impact on words tested in the in-context condition. Since the only cues for word recognition provided in the context-free testing condition are those in the graphic word representation, it appears that children were learning to respond to these cues while they read the words in context in the repeated reading condition. This finding is important, because it suggests that the repeated reading technique can produce <u>generalized</u> increases in text processing fluency at least partially because it enables children to respond more rapidly to the graphic cues contained in individual words. These words will then be read more rapidly and accurately, regardless of the context in which they appear.

Our second point of discussion involves the question of the relative efficiency of the two techniques in producing mastery. The answer to this question, of course, depends to a large extent on the way each technique is implemented in its specific computer program. As it turned out in this study, the context-free technique simply required more time to execute many of its operations than did the repeated reading technique. Although careful procedures were employed to deduct noninstructional time from the actual time spent using the lessons for both conditions, the adjusted times for the two instructional techniques may not be equivalent. That is, the adjusted time in the context-free technique may not be representative of all context-free techniques, such as the use of flashcards by teachers. The question of relative efficiency might be answered differently if a different computer program had been used to present the context-free method.

The point remains, however, that even though the repeated reading technique required children to read stories containing many words in addition to the target words, it was still a relatively efficient way to improve children's sight vocabulary. Because this technique may also provide experience that improves general text-processing and comprehension skills (Moyer, 1982), it seems a very promising method to help children increase the fluency of their reading. A major constraint on the use of the technique, however, is that children must have sufficient reading skill in order to read and comprehend connected text before it can be used effectively.

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Table 1

Diagram of Experimental Design

Week Number	Group 1	Group 2
1	Repeated reading, Word set A	Context-free, Word set A
	Immediate posttest, Word sets A and E	Immediate posttest, Word sets A and E
2	Context-free, Word set B	Repeated reading, Word set B
	Immediate posttest, Word sets B and F	Immediate posttest, Word sets B and F
3	Repeated reading, Word set C	Context-free, Word set C
	Immediate posttest, Word sets C and G	Immediate posttest, Word sets C and G
4	Context-free, Word set D	Repeated reading, Word set D
	Immediate posttest, Word sets D and H	Immediate posttest, Word sets D and H
7	Delayed posttests, Word sets A - H	Delayed posttests, Word sets A - H

NOTE: Wordsets A - D consist of to-be-taught words, and wordsets E - H consist of non-treatment words.

Table 2

Percentage of Words in Sight Vocabulary and Speed of Response as a Function of Instructional and Posttest Conditions

Instructional Condition		Posttest Condition: Immediate Context-Free	Posttest Condition: Delayed In-Context	Posttest Condition: Delayed Context-Free
Repeated Reading				
Percentage of words	X	88	88	62
	SD	18	14	29
Speed of response	X	1.9	1.0	2.1
	SD	.44	.46	.44
Context-Free				
Percentage of words	X	61	74	41
	SD	33	25	32
Speed of response	X	1.9	1.1	2.1
	SD	.45	.56	.43
Non-Treatment Control Condition				
Percentage of words	X	09	52	10
	SD	16	24	16
Speed of response	X	2.3	1.3	2.2
	SD	.45	.57	.45

Note: Speed of response reported in seconds

Table 3

Actual and Adjusted Time to Master a Word in Both Instructional Conditions

Instructional Condition		Minutes per Word, Actual Time	Minutes per Word, Adjusted Time
Repeated Reading	X	3.36	2.77
	SD	3.08	2.64
Context-Free	X	12.57	8.07
	SD	15.89	10.59